Ottv Performance In Indonesia, Malaysia And Singapore With A Case Study of The Financial Information And Technology Center Building of The Ministry of Finance of The Republic of Indonesia In Jakarta

Rakhmat Setiadi[1]*, Inavonna[2]

[1,2]Master of Architecture Study Program, Faculty of Civil Engineering and Planning, Trisakti University, Jakarta, Indonesia
Coresponden author:
Email: rakhmatsetiadi2112@gmail.com

Abstract.
Thermal comfort is essential for the human body to function effectively (at home, school, or in the workplace). A building's thermal performance is one of the primary factors determining the occupant's thermal comfort level. OTTV is an indicator of the building envelope's thermal performance. OTTV (Overall Thermal Transfer Value) is a measure of how much heat from outside the building enters the room through the building envelope (walls, glass, windows, and roof). This value is used to assess the building's thermal performance and energy efficiency. In Indonesia, Malaysia, and Singapore, OTTV performance is measured using formulas established by each country. This study aims to compare three methods for assessing heat transfer through the building envelope in the case of the same office building facade: Singapore's Envelope Thermal Transfer Value (ETTV), Malaysia's Overall Thermal Transfer Value (OTTV), and Indonesia's Overall Thermal Transfer Value (OTTV). These three methods historically originate from the same building regulatory framework, namely ASHRAE Standard 90A-1980 and the ASEAN-USAID/Lawrence Berkeley Laboratory energy conservation program, which were then adapted nationally by each country. A quantitative descriptive method with a comparative approach is applied to measure the Overall Thermal Transfer Value (OTTV) Performance, so that the measurements can be converted to applicable regulations. This case study clearly shows that with the same facade geometry and forming materials, different OTTV/ETTV index values are produced in the three countries with the same compliance result of Not Met. However, these results cannot be compared directly. The dominant heat gain component is solar radiation through fenestration. The implication is that practical design optimization needs to prioritize WWR control, glass thermal performance, and external shading design. Improvements in the U-value of the solid wall and the absorptivity of the solid wall are still beneficial, but in this case it is still less of a priority than solar heat control through fenestration.
Keywords: *Thermal comfort, thermal performance, OTTV performance and ETTV.*

I. INTRODUCTION

Office as a place of work is a term that refers to activities, workplaces, or systems related to administrative management, both government and private, management, and organizational operations, both for administration and services of government and private institutions (companies). The office in question is in the form of a physical building and all activities within it. One of the most influential things in employee performance is thermal comfort which is greatly influenced by the room temperature in the office space. The object of research that will be conducted is the Information and Technology Center Building of the Ministry of Finance of the Republic of Indonesia (Pusintek) which is an Office Building with activities in Pusintek implementing working hours into 3 shifts so that Pusintek activities are always monitored, so that Pusintek employees work outside normal working hours, namely night and morning shifts.

Thermal comfort is very necessary for the body so that humans can carry out activities well (at home, school or in the office/workplace). Szokolay in the 'Manual of Tropical Housing and Building' states that comfort depends on climate variables (sun/radiation, air temperature, air humidity, and wind speed) and several individual/subjective factors such as clothing, acclimatization, age and gender, obesity level, health level, types of food and drinks consumed, and skin color. (Basaria Talarosha, 20025). Reducing indoor air temperature can be done by providing sun protection from plants placed vertically or horizontally, but in general it cannot produce the expected comfort of occupants, because it can only reduce about 1.5 to 2oC indoor air temperature. According to Fanger (1982), thermal comfort refers to the metabolic rate that can be assessed with variables that include activity, clothing resistance, air temperature, relative humidity, air flow rate, and light intensity. Two groups of variables, namely (1) personal physiological variables including activities and clothing heat resistance, and 2) climate variables including air temperature, air speed, relative humidity and radiation temperature help to define thermal comfort expectations (Eddy Imam Santoso, 2012).

Thermal performance is the ability of a building, building element, or building system to regulate and respond to thermal conditions (heat) in the environment, with the aim of creating thermal comfort for occupants and saving energy used for heating or cooling. The term "thermal performance" generally refers to an object's efficiency in resisting or preventing heat transfer. This is usually related to the thermal conductivity of the material or material assembly. A building's thermal performance will affect the occupants' thermal comfort. Several researchers distinguish between thermal comfort and thermal performance. Thermal performance relates to how a building creates comfortable variables, while thermal comfort is the standard of comfort experienced by building occupants. Thermal performance will result in optimal building design. (Hermawan, Nasyiin Faqih, Annisa Nabila Arrizqi, 2022). One indicator of thermal performance is the OTTV performance. OTTV (Overall Thermal Transfer Value) performance is a measure of how much heat from outside the building enters the room through the building envelope (walls, glass, windows, and roof). This value is used to assess the thermal performance and energy efficiency of a building.

OTTV performance in Indonesia, Malaysia, and Singapore has regulations that have been established by the relevant parties (stakeholders) of each country. The authorities that determine these regulations have created formulas to calculate OTTV performance and set the required baseline to achieve comfortable conditions and energy efficiency. OTTV performance in Indonesia, Malaysia, and Singapore uses different calculation standards in each country. Comparison of three methods for assessing heat transfer through the building envelope in the case of the same office building facade: Envelope Thermal Transfer Value (ETTV) Singapore, Overall Thermal Transfer Value (OTTV) Malaysia, and Overall Thermal Transfer Value (OTTV) Indonesia. These three methods historically stem from the same building regulatory framework, namely ASHRAE Standard 90A-1980 and the ASEAN-USAID/Lawrence Berkeley Laboratory energy conservation program, which were then adapted nationally by each country. (Janda, K.B. & Busch, J.F., 1994).

Some issues that are considered in calculating OTTV Performance from the Ministry of Finance's Pusintek Building in Jakarta using standards from Indonesia, Malaysia and Singapore to find out the calculation standards in the 3 countries and calculate OTTV Performance based on the standards of each country to find out the results of the OTTV Performance and examine why the calculation standards of the 3 countries are different. The purpose of the researcher is to find out the OTTV Performance calculation standards in Indonesia, Malaysia and Singapore and find out the calculation results from the standards of the three countries with a case study at the Pusintek Building and compare the similarities and differences in calculating OTTV performance with formulas from Indonesia, Malaysia and Singapore.

II. LITERATURE REVIEW

OTTV performance is influenced by the building envelope of the building being studied. The main functions of the building envelope on thermal comfort are as follows: 1) Thermal Insulation, which can reduce heat transfer into the room, 2) Thermal Capacity which affects how the building absorbs and releases heat. Materials with high thermal capacity, such as concrete or brick, can absorb heat during the day and release it at night. This can help stabilize indoor temperatures, especially in environments with large day and night temperature differences, 3) Window Type and Placement, Glass Effects and Sun Direction: Windows with special coatings (low-emissivity or low-E coating) can reduce heat radiation from sunlight. Good window placement on the side that is less exposed to direct sunlight can also help reduce the amount of heat entering, double-glazing, windows with double glass or even triple glass are more effective in reducing heat transfer because they have a layer of air or gas that slows down heat conduction, 4) Reflective Layer, the building envelope can be equipped with a reflective layer (such as on a reflective roof) that functions to reflect sunlight and reduce the heat absorbed by the building. In hot climates, this technique is very effective in keeping indoor temperatures low, 5) Use of Plants or Vegetation, green roofs or plant walls can reduce the heat entering the building. Vegetation absorbs sunlight and helps cool the surrounding air through the process of evapotranspiration, thereby reducing the heat transmitted into the building.

Building orientation affects OTTV performance; proper orientation can result in good OTTV performance. Likewise, with building eaves, if they are wider, they can help reduce solar radiation entering the room, thus achieving more comfortable thermal performance. (Ardiyanto, 2015). Buildings with East and West orientations will receive more solar radiation than North and South. Therefore, when planning openings, openings to the East and West require more special attention. If the building is located in a dense and well-organized environment, it will no longer be possible to rely on the ideal orientation of North and South, and avoid the East and West. Therefore, other elements need to be added to reduce East and West solar radiation. (Lili Kusumawati, 2018). A comparison of OTTV Performance calculation standards in Indonesia, Malaysia, and Singapore is as follows:

Country	Main Standard	Sheath Index	Baseline
Singapore	Code on Envelope Thermal Performance for Buildings (BCA, 2008)	ETTV for buildings non-residential air-conditioned	50 W/m2
Malaysia	MS 1525:2014 Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings	OTTV for building envelope nonresidential	50 W/m2
Indonesia	SNI 6389:2020 Conservation of Envelope Energy Buildings in Buildings	OTTV for building envelope conditioned	35 W/m2

Source: BCA (2008), Department of Standards Malaysia (2014), and BSN (2020).

The formula for calculating OTTV performance in Indonesia, Malaysia and Singapore is in the following table :

Method	**Massive Wall Conduction**	**Fenestration Conduction**	**Solar Radiation**
ETTV Singapore	12(1−WWR)Uw	3.4(WWR)Uf	211(WWR)(CF)(SC)
OTTV Malaysia	15α(1−WWR)Uw	6(WWR)Uf	194(OF)(WWR)(SC)
OTTV Indonesia	αUw(1−WWR)TDEk	Uf(WWR)ΔT	SC(WWR)SF

Information :
WWR = window-to-wall ratio; Uw = U-value of solid wall; Uf = U-value of fenestration; α = solar absorptivity; TDEk = equivalent temperature difference; ΔT = design temperature difference; SC = shading coefficient; SF = solar factor; OF = orientation factor; CF = correction factor.

III. RESEARCH METHODS

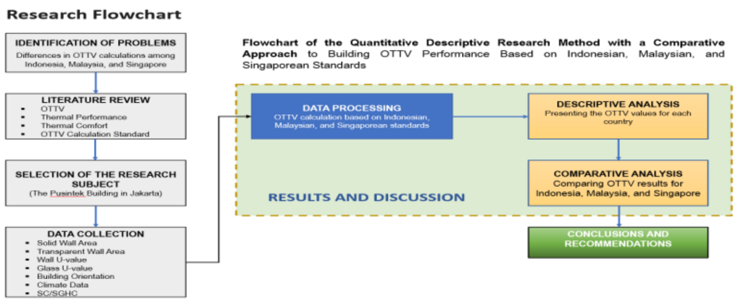
This study employs a quantitative descriptive method with a comparative approach. The descriptive method is used to calculate and describe the Overall Thermal Transfer Value (OTTV) based on building envelope data, including wall area, glazing area, U-value, and shading coefficient. Subsequently, the comparative approach is used to compare the OTTV calculation results based on Indonesian, Malaysian, and Singaporean standards to determine differences in building thermal performance under each standard. Quantitative descriptive analysis is used to describe a variable based on data obtained through measurement, observation, or documentation, while the comparative approach is used to compare differences between two objects, groups, locations, time periods, or specific conditions. The aim of this research using the quantitative descriptive method with a comparative approach is to :

1. Describe the characteristics of a research object quantitatively.
2. Identify differences or similarities between the objects being compared.
3. Draw conclusions based on the analysis results.

Steps in conducting the research:

1. Define the research problem.
2. Identify the variables to be analyzed and select the case study for the research object.
3. Collect quantitative data.
4. Calculate OTTV performance and describe the data using the OTTV calculation standards of Indonesia, Malaysia, and Singapore.
5. Conduct a comparative analysis of the research objects.
6. Draw conclusions.

The research process flow—utilizing a quantitative descriptive method with a comparative approach—that we have designed can be outlined as follows.



When conducting research, the location and building serving as the research subject must be clearly defined to ensure the study aligns with its intended objectives. The Information and Technology Center Building of the Ministry of Finance of the Republic of Indonesia is an eight-story structure situated within the Ministry of Finance complex at Jl. Dr. Wahidin Raya No. 1, Ps. Baru, Sawah Besar District, Central Jakarta City, Special Capital Region of Jakarta 10710.

Fig. 1. Location of the Pusintek Building

Fig. 2. Building Elevation

IV. RESULTS AND DISCUSSION

Calculations of OTTV performance in Indonesia, Malaysia, and Singapore yield different OTTV values because the formulas used also differ. To calculate OTTV performance, one must consider the building envelope components that influence it.

Location of Research Object

Fig. 3. Location of the Pusintek Building

Research Object Layout Plan

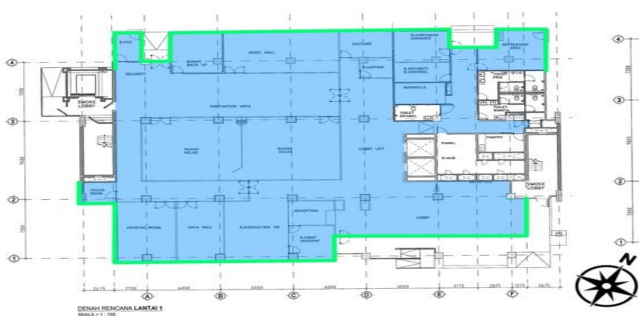


Fig. 4. Floor Plan 1 **Fig. 5. Floor Plan 2**

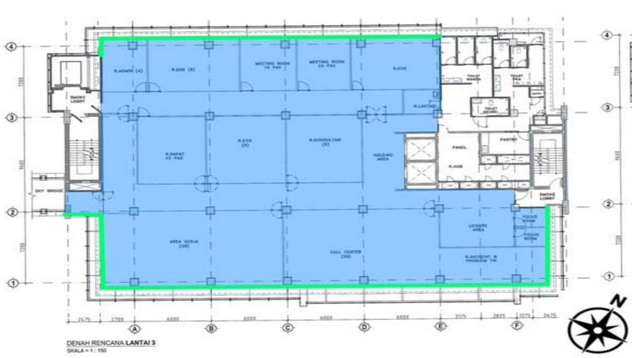


Fig. 6. Floor Plan 3

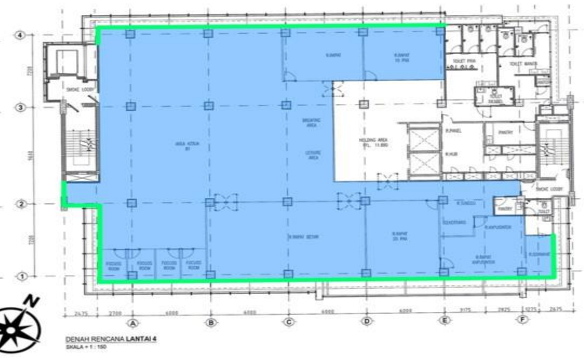


Fig. 7. Floor Plan 4

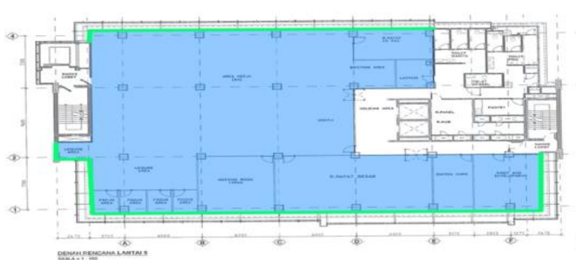


Fig. 8. Floor Plan 5

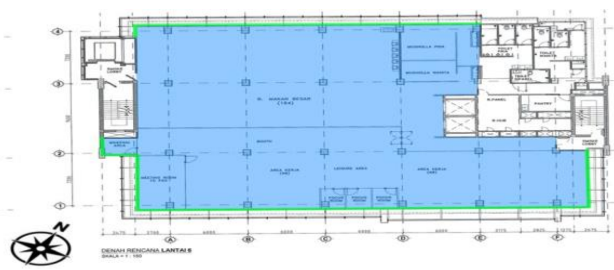


Fig. 9. Floor Plan 6

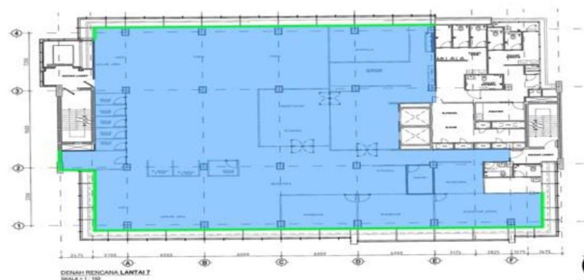


Fig. 10. Floor Plan 7

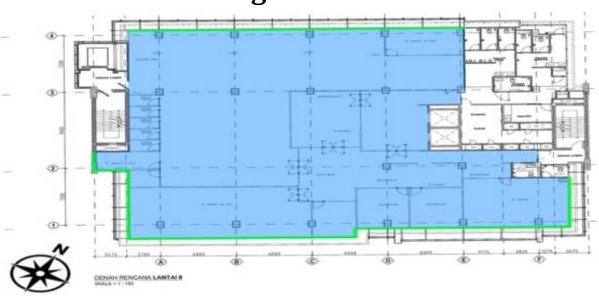


Fig. 11. Floor Plan 8

Conditioned Area

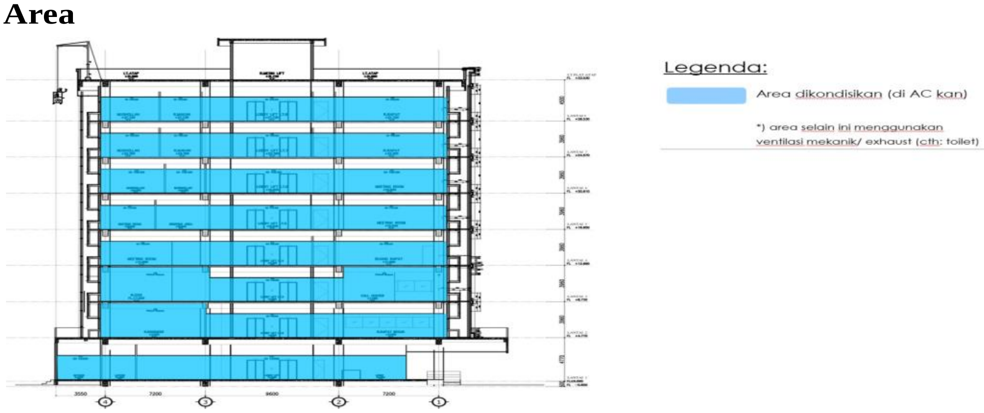


Fig. 12. Conditioned area and calculation limits

Identification of Solid Wall Materials and Transparent Walls

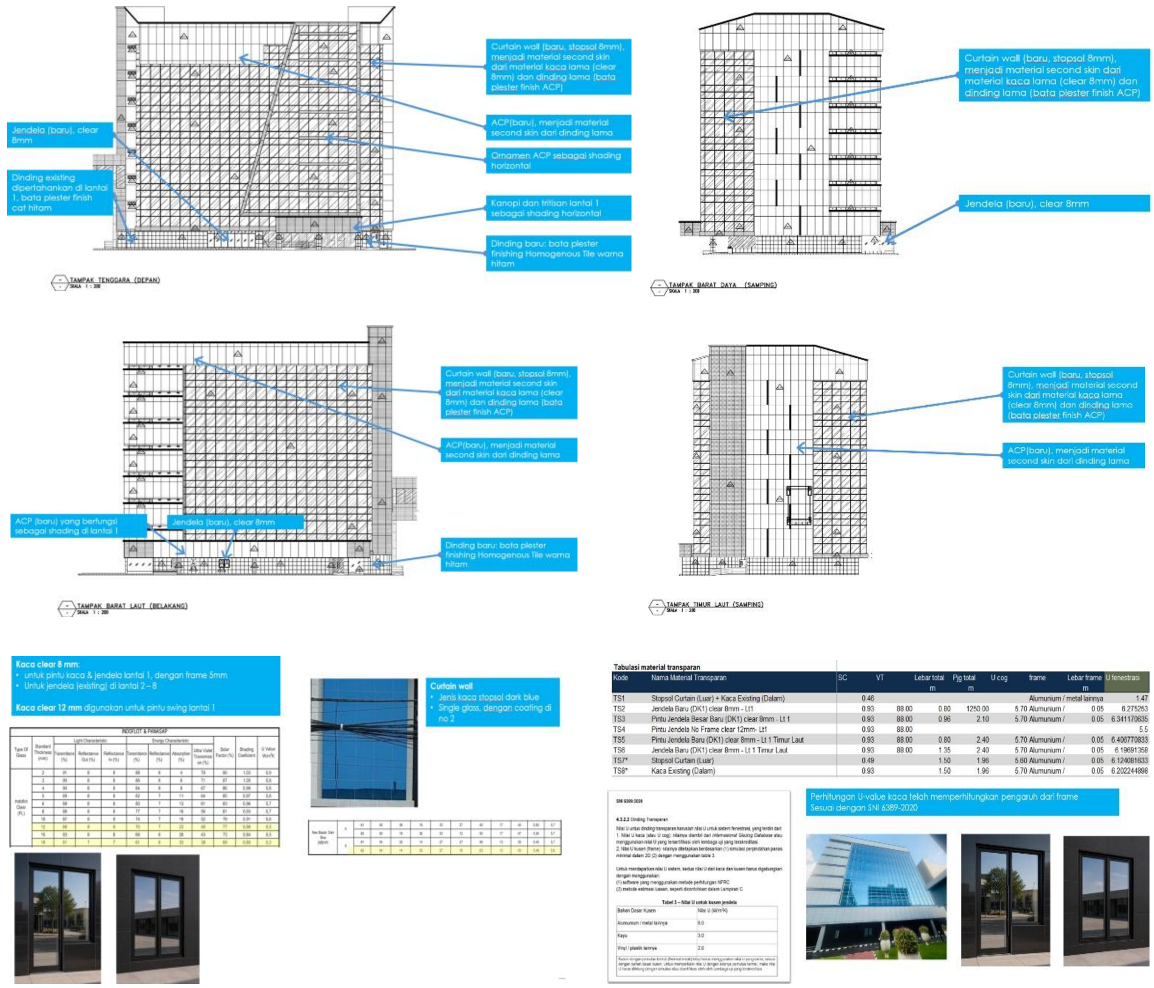


Fig. 12. Identification of massive and transparent materials

Tabulasi material massive fasad

Kode	Nama Massive Material	Alpha Total	Uvalue	TDEK
MS1	001 Dinding Brick /Bata Merah, Finish HT Hitam	0.55	3.18	10.00
MS2	002 Dinding Brick /Bata Merah, Finish Cat Hitam	0.85	2.79	10.00
MS3	003 Dinding Exisiting + Finish ACP Existing + Curtain Wall Baru	0.10	1.16	10.00
MS4	004 Kolom Beton (700mm)	0.86	1.54	10.00
MS5	005 Kolom Beton (350mm)	0.86	2.46	10.00
MS6	006 Dinding Exisiting + Finish ACP Existing + ACP Baru	0.10	1.46	10.00
MS7*	007 Kaca Existing (dalam) + Curtain wall Stopsol (luar)	0.00	1.47	15.00

Summary of OTTV Performance Calculation

Indonesian Standard OTTV Calculation : SNI 03-6389-2020

No	Orientation	Facade area sqm	Opening area sqm	WWR %	Massive Conduction W	Fenestration Conduction W	Radiation W	Total Heat W	OTTV W/sqm
1	Tenggara	796,45	336,45	0,42	1.072,59	3.727,68	23.041,26	27.841,53	34,96
2	Barat Daya	278,30	95,07	0,34	794,51	698,77	6.585,24	8.078,53	29,03
3	Barat Laut	619,48	249,51	0,40	2.142,25	2.153,66	21.170,49	25.466,41	41,11
4	Timur Laut	171,02	85,24	0,50	133,87	1.134,38	7.812,63	9.080,88	53,10
Summary		1.865,25	766,28	0,41	4.143,23	7.714,50	58.609,62	70.467,35	37,78

Malaysian Standard OTTV Calculation: Malaysian Standard MS 1525:2014

No	Orientation	Facade area sqm	Opening area sqm	WWR %	Massive Conduction W	Fenestration Conduction W	Radiation W	Total Heat W	OTTV W/sqm
1	Tenggara	796,45	336,45	0,42	3.567,22	4.473,22	35.409,86	43.450,31	54,55
2	Barat Daya	278,30	95,07	0,34	2.187,69	838,53	7.564,36	10.590,58	38,05
3	Barat Laut	619,48	249,51	0,40	4.299,22	2.584,39	20.567,40	27.451,02	44,31
4	Timur Laut	171,02	85,24	0,50	425,18	1.361,25	10.524,72	12.311,14	71,99
Summary		1.865,25	766,28	0,41	10.479,31	9.257,39	74.066,34	93.803,05	50,29

Singapore Standard ETTV Calculation: CODE ON ENVELOPE THERMAL PERFORMANCE FOR BUILDINGS

No	Orientation	Facade area sqm	Opening area sqm	WWR %	Massive Conduction W	Fenestration Conduction W	Radiation W	Total Heat W	ETTV W/sqm
1	Tenggara	796,45	336,45	0,42	7.547,77	2.504,04	34.525,15	44.576,96	55,97
2	Barat Daya	278,30	95,07	0,34	3.356,47	475,17	9.689,83	13.521,47	48,59
3	Barat Laut	619,48	249,51	0,40	6.605,03	1.446,25	25.419,80	33.471,09	54,03
4	Timur Laut	171,02	85,24	0,50	1.218,45	749,36	9.931,75	11.899,56	69,58
Summary		1.865,25	766,28	0,41	18.727,72	5.174,82	79.566,53	103.469,07	55,47

Table 1. Summary of OTTV / ETTV Performance Calculation Results in Indonesia, Malaysia and Singapore

From the calculation results in Indonesia, Malaysia and Singapore with the baseline from each country, the calculation results from the three countries are not met, OTTV performance is still above the baseline set by each country, the comparison results are in the following table.

Summary of OTTV Performance Calculation in 3 Countries (Indonesian, Singapore dan Malaysian)

No	Orientation	OTTV / ETTV (W/m2)		
		INDONESIAN	SINGAPORE	MALAYSIAN
1	Tenggara	34,96	55,97	54,55
2	Barat Daya	29,03	48,59	38,05
3	Barat Laut	41,11	54,03	44,31
4	Timur Laut	53,10	69,58	71,99
Summary		37,78	55,47	50,29

BASELINE	**35**	**50**	**50**
CONCLUSION	**does not meet the**	**does not meet the**	**does not meet the**

Tabel 2. Comparison of OTTV Performance Calculation Results in Indonesia, Malaysia, and Singapore

Comparative Analysis of OTTV Performance in Indonesia, Malaysia and Singapore

1. Same heat gain structure

All three methods break down facade heat gain into three components: heat conduction through the solid wall, heat conduction through the fenestration, and solar radiation transmitted through the fenestration. This same structure has been confirmed by various studies as a universal framework for the thermal assessment of building envelopes in tropical and subtropical climates, with its historical roots traced back to the formulation by Chou and Lee (1988), using DOE-2 simulations for a generic commercial building in Singapore. The main differences between the standards lie in the individual parameters that constitute the components, not in the underlying thermal model. Thus, the essential difference lies in the decision of each standard-setting body to retain certain variables explicitly or to condense them into calibrated coefficients. Research on the comparison of OTTV coefficients across climate zones indicates that each approach is a simplification of the same model with varying degrees of explicitness.

2. Component 1: Massive Wall Conduction

Massive wall conduction is represented by the wall U-value and the non-transparent wall fraction (1−WWR). The main difference lies in the treatment of solar absorptivity (α) and equivalent temperature difference (TdeK) of the three standards.

Table 3. Comparison of Indonesia, Malaysia and Singapore for Massive Wall Components

Indonesia	Malaysia	Singapore
The Indonesian National Standard (SNI) makes these two elements explicit through the formulation αUw(1−WWR)TDEk. Thus, the calculation remains sensitive to the color or absorptivity of the wall material as well as the wall mass through TDEk. The concept of equivalent temperature difference (TDEk/TETD) is rooted in the sol-air temperature approach: the sol-air temperature is the equivalent outside air temperature that produces the same heat transfer rate as the combination of solar radiation, convection, and radiative exchange. The TDEk value varies based on the weight per unit area of the material; the higher the wall mass, the greater the time lag and the smaller the decrement factor. Keeping TDEk explicit makes the SNI more sensitive to the choice of material and wall mass..	MS 1525 Malaysia maintains the absorptivity explicitly through the coefficient α, but compresses the equivalent temperature difference into a fixed constant of 15 K. Research in Malaysia found that the external wall surface absorptivity affects the chiller load by 8–9%, which provides the technical justification for including α as an explicit variable in the wall conduction term. A study of the thermal performance of double brick walls in a multi-story hotel envelope in Malaysia also confirmed a significant relationship between the measured wall surface temperature and the theoretical sol-air temperature..	Singapore's ETTV further compresses the wall conduction term to 12(1−WWR)Uw, without explicit α or TDEk. The most plausible technical interpretation is that Singapore embeds the average sol-air effect into the national empirical coefficients, which are calibrated through Singapore-based DOE-2 climate simulations. This interpretation is consistent with the research lineage of Chou and Lee (1988), Chou and Chang (1996), and Chou et al. (2007)..

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3. Component 2: Fenestration Conduction

Physically, fenestration conduction is a U × A × ΔT process. Indonesia maintains this structure explicitly through the form Uf(WWR)ΔT with a constant ΔT of 5 K. Singapore states this value as 3.4 K and Malaysia as 6 K.

Indonesia	Malaysia	Singapore
Uf(WWR)ΔT	6(WWR)Uf	3.4(WWR)Uf

The ΔT coefficients should not be interpreted simply as literal temperature differences between the three countries. Research on the OTTV coefficients indicates that these coefficients are the result of statistical modeling of energy simulations based on local climate and specific building typologies, including operational schedules, internal loads, and HVAC system assumptions. (Devgan, S., Kaur, J., Mathur, J. & Garg, V., 2010). Therefore, the ΔT coefficients are more appropriately understood as simplified national standards that combine temperature difference assumptions with national consensus chosen by each country. (Yik, F.W.H. & Wan, K.S.Y., 2005).

4. Component 3: Solar Radiation through Fenestration

Solar radiation through fenestration is the most dominant and most sensitive component to climate. [10,21] Indonesia uses a Solar Factor (SF) table based on each city and orientation. This approach is consistent with Indonesia's geographical diversity. A BIM-based OTTV study of three geographically diverse Indonesian cities, Banda Aceh (northern hemisphere), Pontianak (northern hemisphere), an (equator), and Yogyakarta (southern hemisphere), empirically shows that the same window design produces significantly different OTTV values in each city due to differences in SF values, so that the validity of the SF table in each city in SNI is scientifically confirmed and is necessary in calculating OTTV on a national scale in Indonesia. Singapore uses a fixed multiplier of 211 combined with a correction factor (CF) based on the orientation of transparent walls and their pitch angle. This approach is appropriate for a relatively small country, where a single national climate baseline is sufficient. A BIM-based OTTV study in Southeast Asia confirmed that variations in solar radiation factors are the most significant differentiating factor between national standards.

Malaysia uses a fixed multiplier of 194 combined with the solar orientation factor (OF). MS 1525 notes that this constant data corresponds to the test-reference-year weather data for Kuala Lumpur. Real-time monitoring studies in Malaysia confirm that the solar radiation component through fenestration contributes 60–70% of the total OTTV value based on MS 1525. (Al-Qadhi, M.A. et al., 2025).

Thus, SF, OF, and CF represent the same phenomenon, solar radiation transmitted through a 3 mm clear glass reference with sensitivity to orientation, but with different calibration strategies and geographic granularity (level of detail) according to the context of each country.

Indonesia	Malaysia	Singapore
SC(WWR)SF	194(OF)(WWR)(SC)f	211(WWR)(CF)(SC)f

5. Determination of the shading coefficient (SC) value

The three standards are essentially aligned in their shading coefficient logic: each uses SC as the ratio of solar heat gain through a specific fenestration system to the heat gain through a reference 3 mm clear glass without shading. The effective shading coefficient is the product of the glass performance and the performance of the external shading device. In Indonesia, it is expressed as SC= SCk× SCeff; in Malaysia as SC = SC1 × SC2; in Singapore, it is expressed as the product of the subsystem shading coefficients. The differences lie primarily in the calculation tools for the shading SC value. Malaysia provides diagrammatic and graphical tools for horizontal, vertical, and egg-crate device projections. Singapore and Indonesia provide the solar geometry method in tabular form. The strong similarity between the Singaporean and Indonesian approaches is consistent with the Indonesian bibliography citing the earlier Singapore ETTV guidelines.

6. Compliance threshold and comparability

The 35 W/m2 threshold in Indonesia and the 50 W/m2 threshold in Singapore and Malaysia are not appropriately treated as directly equivalent benchmarks. Research examining the appropriateness of using OTTV as an indicator of building envelope performance shows that the OTTV coefficient is the result of statistical modeling regression on energy simulations based on local climate conditions and specific building characteristics, so the resulting index values are tied to the formulation system that generates them. (Chow, W.K. & Chan, K.T., 1998). The formulations from the three countries are calibrated differently to the conditions in each country. A direct comparison between Indonesia's OTTV figures and Singapore's ETTV for the same building is physically inappropriate, because the formula coefficients and the climate data embedded in them differ. Research on predetermined OTTV coefficients for various climate zones confirms that using coefficients from one climate zone for buildings in another climate zone produces index val ues that are not mutually representative. (Devgan, S., Kaur, J., Mathur, J. & Garg, V., 2010). A proper cross-country performance comparison requires recalculation using the same method, or simulation of the entire building using the same weather files, schedules, internal loads, and HVAC assumptions. (Siu, C.Y. & Liao, Z., 2020).

Discussion of OTTV Performance in Indonesia, Malaysia and Singapore

The geometry and constituent materials of the project in this case study were held constant across all three calculations. The gross facade area was 1,865.25 m2, the fenestration area was 766.28 m2, and the overall WWR was 0.41 across all three calculations. Therefore, the observed numerical differences are primarily driven by the calculation method, coefficient selection, and treatment of climate factors. This case study shows that with the same facade geometry and constituent materials, the three methods yield different index values and a compliance status of Not Compliant in the three countries, with varying deviations from their respective baselines. Malaysia had the lowest deviation from its national standard baseline, while Singapore had the highest deviation.

Table 10. Summary of case study calculation results under three national methods

Metode	Fasad (m²)	Fenestrasi (m²)	WWR	Total heat (W)	OTTV/ETTV (W/m²)	Baseline (W/m²)	Deviasi
OTTV Indonesia	1.865,25	766,28	0,41	70.596,33	37,85	35	8,14%
ETTV Singapura	1.865,25	766,28	0,41	103.469,07	55,47	50	10,94%
OTTV Malaysia	1.865,25	766,28	0,41	93.803,05	50,29	50	0,58%

Based on the analysis, cross-country comparisons of case study results are not appropriate (not apple-to-apple) because each component of the model coefficients depends on local climate levels, sub-national variations, and national consensus decisions. Research on the comparison of building energy simulation tools confirms that even when using the same tool for the same building, differences in input assumptions can result in significant output discrepancies.

Interpretation of the heat transfer components, from the case study calculations, the pattern of res ults confirms that solar radiation through fenestration is the determining component because its portion is very dominant in all three calculations. Although the components of solid wall conduction and fenestration conduction vary between national methods, the radiation component contributes about three-quarters or more of the total envelope heat gain in each method. The same pattern is found in other calculations, which indicates that this pattern is mathematically sound.

Table 11. Portion of heat gain components according to the national calculation method

Method	Wall conduction portion	Fenestrated conduction portion	Solar radiation Portion
OTTV Indonesia	6,1%	10,9%	83,0%
ETTV Singapura	18,1%	5,0%	76,9%
OTTV Malaysia	11,17%	9,87%	78,96%

Therefore, the most influential façade design factors are reducing WWR, selecting glass with lower SC or SHGC, and external shading strategies that reduce direct solar radiation transmission. A BIM-based sensitivity study of 3,600 window variations in three Indonesian cities showed that WWR has a more significant influence on OTTV values than SC, with a reduction of up to 46 W/m2 when WWR is reduced from 65% to 25%. The application of external shading devices in office buildings in Indonesia has been shown to reduce OTTV values from 69.57 W/m2 to 31.57 W/m2, a decrease of 55%, confirming the effectiveness of shading strategies as a design optimization priority. (Wahyudi, M.B., Munir, S. & Afifuddin, 2023). Improvements in the U-value of solid walls and absorptivity of solid walls are still beneficial, but in this case, it is still a lesser priority than solar heat control through fenestration.

OTTV and ETTV are simplified steady-state indices of envelope heat gain, not full dynamic thermal simulations. Chou and Lee (1988) developed a simplified OTTV equation using DOE-2 simulation results as the heat gain database. Chou and Chang (1996) discussed a general methodology for determining total heat gain through a building envelope, and Chou et al. (2007) prepared a project report supporting the current Singapore ETTV criteria (Chou, S.K., Liew, H.T., Ko, J.R. & Goh, A., 2007). These sources explain why the Singapore method uses constants and calibration correction factors, rather than exposing all climate and material variables in the final compliance equation. Regional and institutional references indicate that the OTTV/ETTV methods in Southeast Asia share common technical roots. The final report of the ASEAN-USAID/Lawrence Berkeley Laboratory Building Energy Conservation Project is cite d in the SNI bibliography, along with the Singapore BCA guidelines. (Janda, K.B. & Busch, J.F., 1994 and ASEAN-USAID and Lawrence Berkeley Laboratory., 1992). Malaysia adopted OTTV in 1987 as an indicator of the thermal performance of the envelope in its commercial building energy standards, while Singapore was the first country in Asia to develop Building Energy Standards (BES), implemented since 1979. This shows that these national methods are not isolated inventions, but rather adaptations of a broader tropical building energy conservation framework to the regulatory and climatic context of each country.

The results of the three calculation cases are consistent with the pattern in the literature that in hot-humid climates, solar heat gain through glazed facades often becomes the dominant envelope load when the WWR is large enough. (Al-Qadhi, M.A. et al. (2025) and Ramadhan, M.A. et al. (2025). Therefore, different national solar coefficients are very important in determining the final results. Methods that use higher solar multipliers or orientation factors will produce higher envelope i ndices even though the geometry and glass input values remain unchanged. Comparison More valid cross-country thermal performance requires the use of a single, uniform reference method or a full dynamic energy simulation that uses the same weather files, operational schedules, internal loads, and HVAC assumptions. (Siu, C.Y. & Liao, Z. (2020) and Ballarini, I. et al. (2021). A detailed comparative study of various building energy simulation tools shows that even with the same tool, differences in input assumptions and weather files result in significant output discrepancies, thus validating the importance of input unification before cross-method comparisons are conducted

V. CONCLUSION AND SUGGESTIONS

Indonesia, Singapore, and Malaysia model the heat gain of building outer facades with the same mathematical model but at different levels of explicitness. Singapore's ETTV is the most compacted form; Malaysia's OTTV with explicit absorptivity but simplified temperature difference; while Indonesia's OTTV is the most explicit and most geographically granular form because it uses TDEk, Δ T, and city-specific SF values. (Yumrutaş, R., Ünsal, M. & Kanoğlu, M., 2007).

The different thresholds of 35 W/m2 and 50 W/m2 cannot be directly compared because the formulations from the three countries are in different formulation processes, based on different climatic conditions, and different national consensus decisions. (Devgan, S., Kaur, J., Mathur, J. &

Garg, V., 2010).

This case study clearly demonstrates that the same facade geometry and materials yield different OTTV/ETTV index values across the three countries, with the same compliance result of Not Met.

However, these results are not directly comparable. A more accurate cross-country performance comparison would require recalculation with a single, uniform reference method or simulation of the entire building using the same weather files, schedules, internal loads, and HVAC assumptions.

In this case study, the dominant heat gain component is solar radiation through fenestration. Consequently, practical design optimization should prioritize WWR control, glazing thermal performance, and external shading design. While improvements to the U-value and absorptivity of the solid wall are beneficial, in this case, they are less prioritized than solar heat gain control through fenestration.

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